Microlensing Results and Removing the Baryonic Degeneracy

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Abstract. One of the biggest obstacles to our full understanding of the global dynamics in Milky Way and other spiral galaxies is uncertainty with respect to the form of baryonic dark matter in galactic haloes. Two basic forms discussed recently are MACHOs and various states of halo gas. We investigate constraints which could be obtained from the empirical microlensing optical depth on combined MACHO + gas models, and show that improved statistics will certainly be able to discriminate between various such models. This has profound consequences not only for galactic dynamics and baryonic budget, but for investigation of the low-redshift Lyα absorption systems and general cosmological distribution of gas.

1. Constraints on the BDM, and BDM halo models

Microlensing (ML) observations revolutionized galactic halo modeling. The abundance and properties of lenses influence the cosmological picture of the abundance, structure and evolution of the baryonic content of the universe.

Widely held assumptions: (I) MACHOs are baryonic, (II) Milky Way is a typical L_* spiral galaxy, are necessary for correct account of baryons, comparison with BBNS bounds (Fields et al. 1998), and comparing local mass census with total mass-energy of the universe. Our assumption: (III) MACHOs possess finite mass-to-light ratios, exclude dense clouds, or stellar-mass black holes from (I).

Unknown baryonic fraction of primordial galactic haloes f_g became acute problem with the discovery of non-zero cosmological constant. It can vary between 0.04 and 0.2, depending on precise values of light element abundances, Hubble constant and cosmological constant (Gates, Gyuk & Turner 1995).

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2. Discussion

Contribution of MACHOs to the total baryonic density, if Milky Way is typical for the present epoch, $\Omega_{\rm MACHO}/\Omega_B \simeq 0.7\,h$ (Fields et al. 1998), is based on ML surveys toward Magellanic Clouds, still in progress. If MACHO halo extends further than the distance to Magellanics, ~ 50 kpc, the ratio also increases.

Inclusion of gaseous phases into Galactic BDM mass budget is based on a persistence of Lyα absorption systems down to low redshifts (*HST* observations), and their proven association with normal galaxies (Fukugita et al. 1998), as diffuse remnants of huge gaseous haloes galaxies once possessed. With maximal absorption radius $\sim 178\,h^{-1}$ kpc (Chen et al. 1998), they are much larger than MACHO haloes, suggesting that amount of gas in various ionization stages around normal luminous galaxies is high, contrary to the conventional wisdom.

High baryon budget, discussed by Milošević-Zdjelar, Samurović & Ćirković (this Conference) and Jakobsen (1998), can not be found in the present-day IGM. We conclude that by the recent epochs, most baryons have been incorporated into collapsed structures of gas of varying ionization stages, and MACHOs.

Extending discussion of Gates et al. (1995) with gaseous phase of halo matter we establish contact between the observed column density and physical density of gas, integrate density over the halo volume, integrate masses of such haloes over Schechter luminosity function, and obtain three density profiles. In model which gives the physical density *a priori*, we may substitute the first step for integration of this density along the line-of-sight in order to compare with the observational data on the column density spatial distribution (Ćirković 1999).

ML results, as manifested in optical depths and event durations, suffer from intrinsic degeneracies which preclude construction of a realistic, 3-D model of lens distribution. Degeneracy could be removed by supplementing ML data with other independent constraints from different branches of astronomy.

The explosive advances recently made in the study of gas around galaxies at low redshift promise that supplementing of this information to the ML data, and taking into account "high-precision era" of BBNS studies, will enable fixing the MACHO abundance and the extent of MACHO halo for L_* galaxies. Composite BDM models may certainly aspire to be more realistic than gas-alone (Mo & Miralda-Escudé 1996) or the MACHO-dominated (e.g. Honma & Kan-ya 1998).

Acknowledgments. Srdjan Samurović acknowledges the financial support of the University of Trieste.

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